

Original Research



Evaluating the effectiveness of a food literacy pilot program for university students: using a mixed-methods research approach

Eunji Ko ^{1,2}, Eunjin Jang ^{1,2}, Jiwon Sim ^{1,2}, Minjeong Jeong ^{1,2}, and Sohyun Park ^{1,2§}

¹Department of Food Science and Nutrition, Hallym University, Chuncheon 24252, Korea

²The Korean Institute of Nutrition, Hallym University, Chuncheon 24252, Korea

OPEN ACCESS

Received: Jan 15, 2024

Revised: Jun 4, 2024

Accepted: Jul 18, 2024

Published online: Oct 10, 2024

Corresponding Author:

Sohyun Park

Department of Food Science and Nutrition, and The Korean Institute of Nutrition, Hallym University, 1 Hallymdaehak-gil, Chuncheon 24252, Korea.

Tel. +82-33-248-2134

Fax. +82-33-256-3420

Email. sopark@hallym.ac.kr

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ORCID iDs

Eunji Ko 

<https://orcid.org/0000-0003-1486-1007>

Eunjin Jang 


<https://orcid.org/0000-0003-3926-4575>

Jiwon Sim 

<https://orcid.org/0000-0003-2381-8641>

Minjeong Jeong 

<https://orcid.org/0009-0005-0686-1666>

Sohyun Park 

<https://orcid.org/0000-0001-6009-1002>

ABSTRACT

BACKGROUND/OBJECTIVES: As awareness of climate change increases, the relevance of environmental education in dietary choices gains prominence. Although diversely defined, food literacy (FL) is increasingly recognized as the ability to make food choices with an awareness of environmental sustainability. This study aims to conduct a pilot implementation and assess the effectiveness of a program developed to improve FL among university students.

SUBJECTS/METHODS: The study spanned from August 2022 to February 2023, involving 92 participants (42 in the intervention group and 50 in the control group). Over 11 weeks, the program included cooking classes, local farm visits, and environmental impact lectures developed through extensive literature reviews and interviews with students and experts. FL was measured using a 33-item survey along with basic sociodemographic factors. After the intervention, both groups participated in qualitative interviews. All statistical analyses were carried out in Stata/SE version 17.0, and interview data were analyzed in Microsoft Excel using the framework analysis method.

RESULTS: The FL scores of the intervention group improved significantly from an average of 65.8 to 69.6 points ($P = 0.015$), with notable gains in the socio-ecological domain in FL from 65.3 to 71.5 points ($P < 0.001$). A linear regression analysis comparing FL between the intervention and control groups found that only the knowledge items were marginally significant ($P = 0.054$), with no statistically significant difference in the practice aspect before and after the intervention ($P = 0.657$). The interviews revealed that the intervention group experienced broadened perspectives and heightened environmental consciousness, although translating these into practice was challenged by unchanged daily routines.

CONCLUSION: This pilot program effectively enhanced some aspects of FL-related knowledge of participants. High satisfaction among participants and no dropouts indicated its potential for scaling. Future programs will benefit from strategies that facilitate the transition from educational improvement to practical application.

Keywords: Food; literacy; young adult; intervention study; climate change

Funding

This research was supported by grants from the basic science research program through the National Research Foundation of Korea (NRF), funded by the Ministry of Education (2021R111A3060248, 2021R1A6A1A03044501).

Conflict of Interest

The authors declare no potential conflicts of interests.

Author Contributions

Conceptualization: Ko E, Jang E, Sim J, Park S; Formal analysis: Ko E, Park S; Investigation: Ko E, Park S; Methodology: Ko E, Park S; Supervision: Park S; Writing - original draft: Ko E, Park S; Writing - review & editing: Ko E, Jang E, Sim J, Jeong M, Park S.

INTRODUCTION

The global average temperature is rising, and the uncertainty surrounding future water resources is increasing [1]. Such uncertainties are expected decrease the global agricultural production and consequently increase food prices [2]. Large-scale livestock breeding for meat consumption contributes to an increase in greenhouse gas emissions [3], food waste generated from nonconsumed food represents fossil fuel waste used in food production. It also contributes to an increase in methane emissions during food waste disposal, thus negatively impacting the environment [4]. The importance of a sustainable diet that has no negative environmental impact and ensures food security and a healthy life for current and future generations is emphasized [5,6].

Nutrition education is vital for practicing a healthy diet and obtaining the necessary nutritional knowledge and skills; it also aims to foster sustained dietary behavior change by positively influencing knowledge and attitudes [7,8]. Although past nutrition education primarily focused on improving individual nutritional status, in the current era of climate crisis, educational strategies that include guidelines for sustainable diets to combat climate change are crucial [9]. Education on sustainable diets, particularly among younger demographics, has the potential to be a critical strategy in combating future climate crises [10].

Food literacy (FL) has recently been identified as an important personal competency for maintaining a healthy diet, with extensive research being conducted in this area [11]. Initial studies focused on the intake of food and cooking skills of individuals [12], but recent research has expanded this definition to include relationships with food and the environment [13]. Yoo *et al.* [14] expanded on existing FL and defined it as the ability to practice a sustainable diet that includes future-oriented environmental values and research on relationships with food and other people. Delphi surveys classified FL into nutrition and food safety domains, including food knowledge and attitudes, cultural and relational domains covering human relationships and traditional food cultures, and socio-ecological domains for sustainable diets. As a result, valid FL measurement items for use in FL education evaluation were developed [15].

A study of FL among Seoul residents found that young adults, including university students, had the lowest levels of FL [16]. FL levels were found to be associated with food intake and obesity, and lower FL scores were significantly correlated with lower fruit and vegetable consumption and higher odds ratios of obesity [16]. The lack of nutrition and cooking education, inadequate experiences, limited access to grocery stores, and community consciousness were cited as reasons for low FL among young adults in qualitative research [17]. Furthermore, similar studies have been conducted in Australia and, as a result, identified barriers that affect FL, such as a lack of educational materials, facilities, and personnel [18], underscoring the need for intervention studies to mitigate these barriers and improve FL.

Recent intervention studies aimed to improve FL among adults to improve food intake and nutritional status. For example, Begley *et al.* [19], analyzed the effects of a FL intervention program aimed at adults from low to middle-income households, focusing on checking nutrition information and cooking and eating within a reasonable budget. The program showed significant improvements in the selection and preparation of food. West *et al.* [20] evaluated the NEST program, developed to improve FL and cooking skills among low-income Australian adults, observing higher nutrition knowledge scores and confidence in cooking

skills. Despite not being solely based on the FL concept, a study of university students showed that an environmentally conscious dietary intervention effectively improved dietary behaviors and knowledge [21].

As highlighted, the vulnerable group in Korea regarding FL is young adults [16], and improving their FL is crucial to promoting health and preventing the transition to chronic diseases. Furthermore, improving the socio-ecological competencies of food choices included in FL is essential for social sustainability and slowing the acceleration of the climate crisis. This study is based on a program developed for FL enhancement among college students through literature reviews, surveys, and interviews with students and experts [22]. This study examined the feasibility and effectiveness of the 11-week campus-based education program on FL through pre and post survey among intervention and control groups. Furthermore, participants' satisfaction and perceived limitations of the program were explored through interviews.

SUBJECTS AND METHODS

Program development

This intervention study is based on the previous research that developed a 11-week curriculum for improving FL among college students. The procedure for program development is described in detail in the previous literature [22]. To briefly summarize the program development process, the final 11-week program was developed through literature reviews, in-depth interviews, expert consultations, and exploration of local community resources. Based on these findings, a consultation meeting with 5 experts in food nutrition, nutrition intervention programs, and service design was held to discuss the FL program's direction. The experts underscored the significance of fostering an environment conducive to promoting healthy eating habits among students, highlighting the necessity for a program facilitating mindful eating practices. Subsequently, the research team crafted an initial program draft utilizing a questionnaire derived from the Seoul Food Survey [15] to gauge students' interest in and willingness to participate in the program. This draft was presented to the young adults, who expressed a likelihood of participation contingent upon direct benefits or applicability to their daily lives. This feedback was used to conduct a second consultation meeting with 2 experts in nutrition intervention and service design.

The program was then revised based on social cognitive theory, aiming to improve self-efficacy through a basic cooking program, increase cooking accessibility by using campus kitchen, and fill in relational and social support elements related to food. Lastly, senior students in the Food and Nutrition Department were recruited as peer educators to enable modeling and observational learning. Exploring campus and community resources led to the selection of location and instructors.

Participants recruitments

The subject of the study involved university students aged 19–29 yrs. Recruitment occurred from June to August 2022 through mobile applications frequently used by students in the Gangwon region. The sample size was determined using the average FL score and standard deviation of a 2021 Seoul Food Survey [23], accounting for a 10% dropout rate, with an alpha of 0.05 and a power of 0.20. The intervention group included 42 undergraduate students from the researcher's university, and the control group included 50 undergraduate students

from other universities in the same region. The program lasted from August 2022 to February 2023, including surveys and interviews. The intervention group participated in the intervention program and both before and after surveys, whereas the control group only took part in both surveys. Six intervention group members were prerecruited as tutors to assist with the program and received 2 FL training sessions before the program started. In addition to FL training, the tutors participated in the program like other participants. The presurvey was conducted in August–September 2022, and the postsurvey in December 2022–January 2023. All surveys were conducted by mobile. Two months after the program ended, follow-up interviews were conducted with a subset of participants. The study was carried out following approval from the Hallym University Ethics Committee (HIRB-0000-009-2-RR).

Implementation of the intervention

The FL program aimed to improve knowledge and attitudes toward a healthy and sustainable diet and its practice. Experts from the community were invited to lead the program, which covered the 3 domains of FL. The participatory classes were 3 h long and included 90 min of theory and 90 min of practice per session. Class times will vary depending on the program topic and instructor.

Conducted as an elective course in the Food and Nutrition Department, the program ran for 11 weeks. Groups of one tutor and 6 tutees each were formed, totaling 6 groups for group activities. If all participants could not attend the actual class due to the narrow space, the program was divided into 2 sections. Participants also completed food diary and other FL-related assignments outside of class time.

Evaluation process

Pre and postintervention structured online survey

Pre and postintervention surveys were conducted online to evaluate the program's effectiveness. Questions with proven reliability and validity were used for the subject's FL level. For each of the 3 areas of FL, a total of 33 questions were asked, including knowledge, attitudes, self-efficacy, and actions [15]. The presurvey gathered information on living arrangements, FL, and sociodemographic characteristics, while the postsurvey recollected the same items while excluding some demographic aspects. The presurvey was completed by 42 intervention group participants and 50 control group participants, whereas the postsurvey had all 42 intervention participants and 45 control participants excluding nonresponders and those who did not meet the participant criteria.

Postintervention qualitative evaluation

Interviews were conducted with 11 participants in the intervention group and 3 in the control group after completing the program. The interviewees from the intervention group were voluntarily recruited and asked about changes in diet, knowledge, and attitudes after participation in the program. They also asked about memorable aspects of the program, areas for improvement, and additional topics of interest. The control group interviews focused on those whose FL scores increased significantly postintervention, exploring changes in their diet during the program and sources of food-related information.

Analysis

Statistical analysis for pre and postintervention surveys

Differences between pre and postintervention values were analyzed using a paired *t*-test. Descriptive statistics calculated the mean and standard deviation for continuous variables, and

for categorical variables, proportions. The results were considered statistically significant if the *P*-value was less than 0.05. Linear regression analysis with gender and age adjustments, with the difference between post and preintervention values as the outcome variable. To identify significant differences, differences between intervention and control groups were examined. Stata 17.0 was used for all statistical analyses (Stata Corporation, College Station, TX, USA).

Framework analysis for interview data

The recorded interview data of the participants were analyzed using framework analysis in Microsoft Excel (2015; Microsoft Corporation, Redmond, WA, USA). Data relevant to FL's 3 main areas and group activities were categorized for the intervention group, with a focus on attitude changes and identifying strengths and weaknesses. For the control group, data were classified according to FL's 3 main areas and the lifestyles of the interviewees. The researchers also compared the summaries with original materials to ensure the reliability of the study results.

RESULTS

Results of the survey data analysis

A total of 87 participants from both intervention and control groups completed all surveys. Upon examining the program participation of the 42 intervention group participants, it was found that 22 (52.4%) completed the entire program, 16 (38.1%) missed one session, and 4 (9.5%) were absent for 2 or more sessions. The demographic characteristics are as follows (Table 1). The intervention group (33.3%) had a higher proportion of male than the control group (17.8%), and there were more female (74.7%) in the study than male (25.3%) The

Table 1. General characteristics of participants in the food literacy program

Characteristics	Intervention group (n = 42)	Control group (n = 45)	Total (n = 87)	<i>P</i> -value
Sex				0.095
Male	14 (33.3)	8 (17.8)	22 (25.3)	
Female	28 (66.7)	37 (82.2)	65 (74.7)	
Age (yrs)				0.443
19–23	37 (88.1)	37 (82.2)	74 (85.1)	
24–29	5 (11.9)	8 (17.8)	13 (14.9)	
Major				0.001
Food Science and Nutrition	30 (71.4)	1 (2.2)	31 (35.6)	
Others	12 (28.6)	44 (97.8)	56 (64.4)	
Living arrangement				0.517
Living with the family	20 (47.6)	16 (35.6)	36 (41.4)	
Living alone	14 (33.3)	16 (35.6)	30 (34.5)	
Shared house	0 (0.0)	1 (2.2)	1 (1.2)	
Dormitory	8 (19.1)	12 (26.7)	20 (23.0)	
Monthly personal income (KRW)				0.052
Less than 0.5 million	16 (38.1)	22 (48.9)	38 (43.7)	
0.5–1 million	23 (54.8)	19 (42.2)	42 (48.3)	
1–1.5 million	3 (7.1)	3 (6.7)	6 (6.9)	
More than 1.5 million	0 (0.0)	1 (2.2)	1 (1.2)	
Monthly food expenses (KRW)				0.365
Less than 0.1 million	4 (9.5)	2 (4.4)	6 (6.9)	
0.1–0.5 million	37 (88.1)	43 (95.6)	80 (92.0)	
0.5–0.7 million	1 (2.4)	0 (0.0)	1 (1.2)	
More than 0.7 million	0 (0.0)	0 (0.0)	0 (0.0)	

Values are presented as number (%).
KRW, Korean won.

control group had a higher percentage of participants aged 24–29 yrs (intervention: 11.9%, control: 17.8%), whereas the majority (85.1%) were between 19 and 23. The intervention group consisted mainly of students in the Food and Nutrition students (71.4%), while the control group consisted mostly of students in other departments (97.8%). In the intervention group, the highest proportion lived with family (47.6%), followed by those who lived alone (33.3%). The proportions of those living with family and those living alone were equal in the control group (35.6%). In the control group, the proportion of people living in dorms was higher (intervention: 19.1%, control: 26.7%). In terms of income and monthly food expenses in Korean Won, more than half of the intervention group earned between 0.5 and 1 million (54.8%), whereas the control group mostly earned less than 0.5 million (48.9%). Most of both groups spent 0.1–0.5 million on food per month (92%). The χ^2 test results showed a significant difference between the 2 groups in terms of their majors ($P < 0.001$), while there was a borderline significance in living expenses ($P = 0.052$).

The results of the analysis of the FL scores with the paired t -test between the intervention and control groups are as follows (**Table 2**). The total FL score of the intervention group increased from 65.8 to 69.6 points out of 100, which was statistically significant ($P = 0.015$). Among the 3 FL domains, socio-ecological FL increased significantly from 65.3 to 71.5 points ($P < 0.001$). The FL for nutrition and safety increased from 66.3 to 69.0 points, but this was not statistically significant ($P = 0.194$). The cultural and relational FL increased from 66.0 to 68.2 points, but this increase was not statistically significant ($P = 0.261$). When the FL measurement tool was observed down into 4 items: knowledge, attitude, self-efficacy, and behavioral skills, there was a significant increase in the knowledge domain ($P = 0.001$). However, no significant differences were observed in the domains of self-efficacy ($P = 0.171$), attitude ($P = 0.068$), or behavioral skills ($P = 0.222$) when compared to baseline.

The control group's postresults, which did not participate in the program, showed a similar increase to the intervention group, prompting regression analysis after gender and age were adjusted (**Table 3**). The overall FL domain scores in the intervention group were higher by an average of 0.2 when compared to the control group, but this was not statistically significant ($P = 0.992$). Only the knowledge domain in FL reached significance ($P = 0.054$).

We analyzed differences in the survey questions to examine the areas where the FL program impacted (**Table 4**). Items such as "I enjoy talking about food with people around me." ($P = 0.047$) and "I enjoy traditional food, which can help protect our cultural identity." ($P = 0.029$) showed a significant increase in the cultural and relational FL, where no significant results

Table 2. Pre- and post-intervention measurements of FL level by subareas

FL score by subareas	Intervention group (n = 42)				Control group (n = 45)			
	Pre	Post	Post/pre Δ	P -value ¹⁾	Pre	Post	Post/pre Δ	P -value ¹⁾
All FL scores	65.8 (10.0)	69.6 (10.2)	3.7 (9.5)	0.015	62.7 (12.1)	65.8 (12.0)	3.0 (8.7)	0.023
NS FL	66.3 (11.6)	69.0 (12.3)	2.7 (13.1)	0.194	63.1 (12.6)	65.7 (14.3)	2.5 (9.3)	0.075
CR FL	66.0 (15.0)	68.2 (14.1)	2.2 (12.3)	0.261	58.9 (16.6)	62.5 (15.5)	3.6 (13.3)	0.076
SE FL	65.3 (10.3)	71.5 (10.5)	6.3 (11.0)	0.001	66.1 (13.6)	69.1 (12.6)	3.0 (11.5)	0.090
Scores for sub-elements ²⁾								
Knowledge	20.8 (3.5)	22.8 (3.2)	2.0 (3.5)	0.001	21.3 (3.3)	21.8 (3.6)	0.5 (2.4)	0.170
Self-efficacy	19.1 (2.7)	19.7 (2.6)	0.6 (3.0)	0.171	18.8 (2.9)	19.1 (3.0)	0.3 (2.4)	0.452
Attitudes	54.8 (6.6)	56.4 (6.7)	1.6 (5.5)	0.068	52.2 (8.3)	54.4 (7.3)	2.1 (6.0)	0.024
Behavioral skills	25.3 (3.4)	26.0 (3.0)	0.7 (3.7)	0.222	23.9 (3.9)	24.9 (3.9)	1.0 (3.2)	0.039

FL, food literacy; NS FL, nutrition and safety food literacy; CR FL, cultural and relational food literacy; SE FL, socio-ecological food literacy.

¹⁾ P -value from paired t -test for pre–post comparisons within each group (2-tailed).

²⁾The entire domain of FL has been reclassified into 4 categories—knowledge, self-efficacy, attitude, and behavioral skills.

Table 3. Pre–post changes in the FL scores between the control and the intervention groups

Characteristics	Coefficient ¹⁾	95% CI	P-value
Intervention group			
All FL	0.2	–3.9, 4.4	0.922
NS FL	–0.5	–5.6, 4.5	0.840
CR FL	–2.3	–8.2, 3.5	0.430
SE FL	3.5	–1.7, 8.6	0.186
Scores for sub-elements ²⁾			
Knowledge	1.3	0.0, 2.7	0.054
Self-efficacy	0.4	–0.8, 1.6	0.553
Attitudes	–0.9	–3.5, 1.8	0.520
Behavioral skills	–0.4	–1.9, 1.2	0.657

FL, food literacy; CI, confidence interval; NS FL, nutrition and safety food literacy; CR FL, cultural and relational food literacy; SE FL, socio-ecological food literacy.

¹⁾Coefficient of difference between pre- and post-intervention measurements compared to the control group. In a linear regression analysis model, gender and age were adjusted. The outcome variable was defined as the difference between the pre- and post-scores. A comparison was made between the control group and the intervention group to examine whether there was a significant difference in the intervention group compared to the control group.

²⁾The entire domain of FL has been reclassified into 4 categories—knowledge, self-efficacy, attitude, and behavioral skills.

were initially observed. Items concerning the environment, such as animal welfare and vegetarianism, were statistically significant. However, in the adjusted regression analysis for gender and age, most results were not statistically significant, except for the item “I know the reasons why animal welfare can be important in purchasing meat and eggs.” which was significant ($P = 0.003$).

Qualitative interview results

Intervention group

Theme 1: Positive evaluation in program participation

Participants in the intervention group positively evaluated the program, citing its practical activities and varied content as beneficial to broadening their perspectives. They appreciated that the program was not difficult and had interesting elements that allowed interaction with fellow participants. The following quote describes the advantages of the student’s participation in the program.

“I was able to meet a lot of people, and it was good to experience various activities that were difficult to experience while living on campus, such as farm experiences. Learning about environmentally friendly and vegan topics, which are difficult to explore on one’s own due to time and information constraints, was particularly beneficial.” (20 yrs old, female)

“Actually, when it comes to food, I only thought of nutrients and put importance on cost-effectiveness, but this time I was exposed to important processes that food goes through before it comes to our table. I think this kind of exposure can lead to a change in the way people look at food.” (19 yrs old, male)

Theme 2: Limitations of program and its implementation

Participants also evaluated the program’s limitations. Some participants were disappointed that there were fewer cooking activities than expected. The class was held at 6 p.m., after regular class hours, as various major students gathered, and some students expressed some negative feelings in this regard. There was also an opinion that the number of group students in each team’s activities was large. The following quote describes the limitations of the student’s participation in the program.

Table 4. Scores for selected items in measuring FL that are heavily covered during the program

Items	Intervention group (n = 42)			Control group (n = 45)			Diff ¹⁾
	Pre	Post	P-value	Pre	Post	P-value	
I can follow a simple recipe.	4.3 (0.7)	4.4 (0.7)	0.596	4.1 (0.8)	4.3 (0.7)	0.088	0.702
I can prepare a meal without difficulty.	4.1 (0.8)	4.2 (0.8)	0.838	4.1 (0.8)	4.0 (0.9)	0.538	0.616
I wash my hands thoroughly before cooking.	4.5 (0.7)	4.4 (0.9)	0.181	4.4 (0.8)	4.5 (0.6)	0.439	0.179
I enjoy cooking.	4.0 (1.0)	4.1 (0.7)	0.472	3.4 (1.2)	3.4 (1.2)	0.743	0.945
I like to eat or share food with my family, friends, and neighbors.	4.2 (0.7)	4.0 (0.9)	0.130	3.6 (1.0)	3.6 (0.8)	0.456	0.125
I enjoy talking about food with people around me.	3.8 (1.0)	4.0 (0.8)	0.047	3.6 (1.1)	3.7 (1.0)	0.523	0.688
I enjoy traditional food, which can help protect our cultural identity.	3.8 (0.9)	4.2 (0.6)	0.029	3.7 (1.0)	3.7 (0.8)	0.824	0.252
I know the reasons why animal welfare can be important in purchasing meat and eggs.	3.6 (0.9)	4.0 (0.9)	0.004	3.8 (0.9)	3.7 (1.0)	0.390	0.003
I believe that reducing meat and promoting vegetarianism helps slow climate change.	3.5 (0.8)	3.9 (0.9)	0.006	3.7 (1.0)	4.0 (0.9)	0.018	0.878
I try to reduce food packaging waste (take-out drinks, delivery foods, etc.).	3.4 (0.9)	3.7 (0.8)	0.046	3.4 (1.0)	3.4 (1.0)	0.868	0.172
I am grateful for the process that has allowed the food to come to the table.	3.2 (0.8)	3.4 (0.8)	0.210	3.0 (1.0)	3.2 (1.0)	0.253	0.648
I am interested in urban agriculture (such as city gardening, weekend farming, etc.).	3.4 (0.9)	3.4 (1.0)	1.000	3.0 (1.0)	3.1 (1.1)	0.430	0.729
I think everyone should have access to quality food regardless of economic circumstances.	4.2 (0.7)	4.2 (0.8)	0.838	4.2 (0.9)	4.3 (0.7)	0.241	0.338
I try to reduce food waste.	3.8 (0.8)	4.0 (0.6)	0.107	3.6 (1.0)	3.9 (0.9)	0.108	0.954
I am interested in urban agriculture (such as city gardening, weekend farming, etc.).	3.7 (1.0)	3.4 (1.0)	0.104	2.9 (1.1)	2.9 (1.2)	0.888	0.457
I try to buy animal welfare products.	2.8 (0.8)	3.1 (0.9)	0.047	2.8 (1.0)	3.0 (1.0)	0.164	0.467
I try to buy eco-friendly agricultural products.	2.9 (0.7)	3.2 (0.8)	0.022	2.9 (1.0)	3.0 (1.0)	0.607	0.130
I try to buy seasonal food.	3.3 (0.9)	3.5 (0.9)	0.070	3.2 (1.1)	3.5 (1.0)	0.078	0.890
I usually try to reduce food waste.	3.7 (0.7)	3.9 (0.7)	0.132	3.6 (0.9)	3.9 (0.7)	0.057	0.777
I try to reduce food waste and food packaging waste (take-out drinks, delivery foods, etc.).	3.5 (0.8)	3.5 (0.9)	0.472	3.4 (0.9)	3.4 (0.9)	0.850	0.423

FL, food literacy.

¹⁾In a linear regression analysis model, gender and age were adjusted. The outcome variable was defined as the difference between post- and pre-values. A comparison was made between the control group and the intervention group to examine whether there was a significant difference in the intervention group.

“As many university students live alone and find it hard to cook for themselves, it would have been better to incorporate more cooking sessions.” (21 yrs old, female)

“The downsides were the late class hours and the large team size, which made it difficult for everyone to become acquainted.” (20 yrs old, female)

Theme 3: Behavioral changes after program implementation

Following the program, some people felt that it was an opportunity to be aware of the environment and reflect on oneself, or that they were trying to practice small things. Some students said they became interested in the environment or practice living a life that considers the environment. The following quote explains the behavioral changes that the students felt while participating in the program.

“Though it’s hard to practice with food, I began paying more attention to the environment in areas like cosmetics and clothing. After attending classes on vegetarianism and animal welfare, I’m drawn more to products labeled vegan.” (23 yrs old, female)

“I looked up articles on vegetarianism. I’ve been exploring various dishes made with vegetables and thinking about trying to make them.” (22 yrs old, female)

Theme 4: Barriers to implementing learned knowledge

There was an opinion that it was difficult to directly translate the learned knowledge into practice. It was difficult to put it into practice due to problems such as lack of confidence and difficulty connecting with participants’ day-to-day activities. Some responded that they understand the problem of the climate crisis, but it was difficult to practice because the

convenience and attractiveness at the moment felt closer. The following quote explains the barriers to implementing the learned knowledge that students felt while participating in the program.

“While listening to the vegetarian or zero-waste lectures, I wondered if I could practice it. ... Imagine that if someone is asked to go vegan for environmental reasons when he/she loves to eat meat dishes. I think it would be very difficult.” (20 yrs old, female)

Control group

Theme 5: Reflection on FL score improvement without program implementation

Interviews with students with high FL scores were conducted in the control group. It was difficult to find any changes in the lives of the control group participants as a result of the interview. However, it was confirmed that the students interviewed were already knowledgeable about nutrition or remembered content from their middle and high schools.

“I cook regularly, about 3–4 times a week. I didn’t take any offline lessons but follow recipes from YouTube channels.” (23 yrs old, female)

“I think I’ve seen it in the textbook that choosing local food and seasonal food has to do with saving the environment.” (22 yrs old, female)

DISCUSSION

According to the 2021 Seoul Food Survey [23], students and young adults were identified as the groups with the lowest FL among adults. While factors influencing FL in young adults have been reported previously [16,24], their application in intervention programs has not been widely tested.

This study evaluated an intervention program designed to improve FL in university students and promoting sustainable eating practices. The analysis before and after the program showed a significant increase in the total score for items in the socio-ecological FL and knowledge measure items in the overall FL for the intervention group compared to the control group. The post-intervention interviews revealed overall satisfaction with the program among the participants in the intervention group, who reported acquiring diverse knowledge and positively evaluating the program.

This study tried to use both quantitative and qualitative data for interpreting study effectiveness. For example, both surveys and post-intervention interviews revealed an enhancement in knowledge regarding the socio-ecological domain. While the survey results did not reach significant values in the practice domain, interviews confirmed some of the barriers such as students not buying their own groceries while living in dorms, which makes it hard to buy animal welfare products. However, we confirmed their gradual willingness to engage in practice in the socio-ecological domain.

Among the previously published studies, few adult intervention programs have been conducted on FL for more than 4 weeks. Post-intervention better meal planning, increased intake of fruits and vegetables, confidence in cooking, increased food preparation behavior, increased nutritional knowledge, and a positive increase in food behavior were all confirmed

in a study of adults in other settings [19,20,25]. These previous studies were only limited to the area of functional FL and did not cover relational and socio-ecological aspect of FL.

Many researchers use various definitions of FL. Recent studies have extended the definition of FL from individual functional domains to include capacities related to cultural, relational, and socio-ecological aspects [14]. Research has shown that individual food-related capacities positively impact other capacities when aligned with environmental and social considerations. For example, Yoo *et al.* [17] found that participants with agricultural experiences, such as weekend farming, had more positive thoughts about fruits and vegetables and consumed more of these food groups. Similarly, another study showed that young adults who valued organic, local foods, and sustainable agriculture ate more fruits and vegetables, ate breakfast more frequently, and ate less fast food, even after controlling for sociodemographic characteristics [26]. This suggests a connection between individual capabilities related to food and environmental and social aspects of food. Therefore, this study demonstrated the feasibility and effectiveness of FL intervention program that targeted young adults with broader meaning of FL encompassing environmental and social aspect of food.

After the 11-week intervention, the participants' knowledge increased, but it did not fully translate into practice. Post-program interviews with participants revealed that they felt the cooking sessions were not enough. The program included a total of 2 cooking sessions per student, which was confirmed to be fewer than students' expectations. Limited cooking opportunities for students with restricted access to cooking facilities in on-campus housing may be insufficient to significantly enhance cooking confidence and skills. As other studies have cited the lack of knowledge and culinary skills among young adults as barriers to adopting sustainable diets [27], it will be important to provide students with ample cooking practice opportunities. Some studies showed that it is difficult for young people to practice their behaviors because social norms are not established to require them to consume sustainable food [28]. Our interview data also showed that giving up meat would not be easy for young adults who like to eat meat dishes after listening to just one lecture on environmental benefits of vegetarianism. Therefore, consistent educational systems and environmental changes are needed to lead young adults to obtain information and to develop skills.

Our dietary habits are closely related to the environment and with the increasing severity of the climate crisis, the importance of sustainable eating practices is emphasized. This study differs from previous research in that it provides information on sustainable dietary practices that benefit the global environment (e.g., reducing packaging waste, food waste, and following a vegetarian diet) and broadening participants' perspectives. As a pilot study, it achieved high satisfaction and completion rates with no dropouts during the academic term, indicating the possibility of program implementation targeting college students. It is also necessary to develop extracurricular curricula that can consistently expose students to such content.

There are some limitations of this study. First, unlike the intervention group, which mainly consisted of students majoring in food and nutrition, the control group had students from various majors ($P < 0.001$). In future research, it is necessary to implement programs with similar composition of students' majors in intervention and control groups to minimize the roles of students major in program effectiveness. Secondly, although the program improved students' knowledge in the intervention group, it did not influence their attitudes and behaviors. Future research needs to explore the proper dose of intervention components

and implement clearer connection between knowledge and skills taught and behaviors that students are expected to develop in their daily campus lives.

This study is significant in evaluating the effects using a control group, conducting qualitative assessments through postinterviews to identify success and failure factors. The intervention program, which links food and the environment through FL and uses the local community and campus, adds value to the research. Future research should address the limitation of knowledge that does not fully translate into behavioral skills, which could lead to the development of educational curricula and institutional arrangements within universities.

ACKNOWLEDGMENTS

We express our deepest gratitude to Hyelim Yoo for conducting the preliminary research on food literacy and providing us with endless affection and help, and to all participants who joyfully participated in this intervention study.

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